



## Short Reports

# Time trends and seasonal variation in acute childhood asthma in tropical Singapore

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## Introduction

Asthma is an important cause of childhood morbidity in Singapore, with cumulative prevalence rising from 3.8 to 20% between 1967 and 1994 (1). It has also been ranked second, only to injuries, as the condition with the highest number of paediatric hospital discharges, and fourth amongst the conditions utilizing the highest number of bed-days (2). Annually, there are more than 3000 hospital discharges for childhood asthma in Singapore (2). Seasonal variations in hospital admissions and Accident and Emergency room (A&E) visits for asthma have been noted in many temperate countries (3–4), and in many instance have been an indicator of potential trigger factors in the environment (4). This study aimed to examine the trends and seasonal variation in hospital admissions and A&E visits for childhood asthma in Singapore using time-series methods.

## Methods

Between January 1990 and July 1996, daily paediatric ( $\leq 12$  years) hospital admissions and A&E visits for two large general hospitals (National University Hospital and Singapore General Hospital), representing approximately 50% of total admissions in Singapore, were analysed. This age group of  $\leq 12$  years was used as it is the cut-off for the paediatric age group for these hospitals. Data was obtained by aged groups (0–2 and 3–12 years) for asthma [International Classification of Diseases (ICD) 493] and acute bronchitis/bronchiolitis (ICD 466). Mid-year estimates of population were obtained from the Annual Yearbook of Statistics, Singapore.

For each age group, the data from both hospitals were summed together, and the estimated rates of A&E visits and hospital admissions per million population were calculated based on the mid-year populations estimates, with adjustment for the missing data from the other hospitals.

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These adjustments were based on the Ministry of Health national annual hospitalization figures for each of the disease categories analysed. The trends for both time series (A&E visits and admission) were estimated using a centred 12-month moving average. The monthly rates were then divided by their corresponding trend values. The resulting values were averaged according to their respective months and expressed as percentage variation about the trend.

Seasonality was evaluated using methods described by Mao *et al.* (5). This involved fitting the data to a series of Box-Jenkins regression-ARIMA (autoregressive integrated moving average) models, which are stochastic models describing a univariate time series as a function of its past values, and then testing for the presence of seasonality.

## Results

### TIME TRENDS

During the period of analysis, more than 3000 admissions and an estimated 9000 A&E visits per annum were recorded for childhood asthma (ICD 493) in Singapore. Figure 1 shows the monthly A&E visit and asthma admission rates and trends for Singapore. To compare acute asthma trends with age, the data was also subdivided into two age groups: 0–2 and 3–12 years. The hospitalization trends in both age groups differed from each other, with a steady trend for the 0–2 years age group, and a rising trend for the 3–12 years group. There were increases above the trend between 1991 and 1992 for the 0–2 years age group, and smaller increases between 1991 and 1992, and in 1994 for the older group. With emergency room visits, gradually increasing trends was observed in both age groups, with similar but less exaggerated increases above the trend in 1991 and 1994 for the 0–2 year olds, and 1994 for the 3–12 year olds.

Since acute bronchitis and bronchiolitis are also common wheezing illnesses in childhood, and trends for these diseases were compared with the trends for asthma (Fig. 2). For both age groups, there was little or no relationship between the trends for asthma and those for acute bronchitis/bronchiolitis.

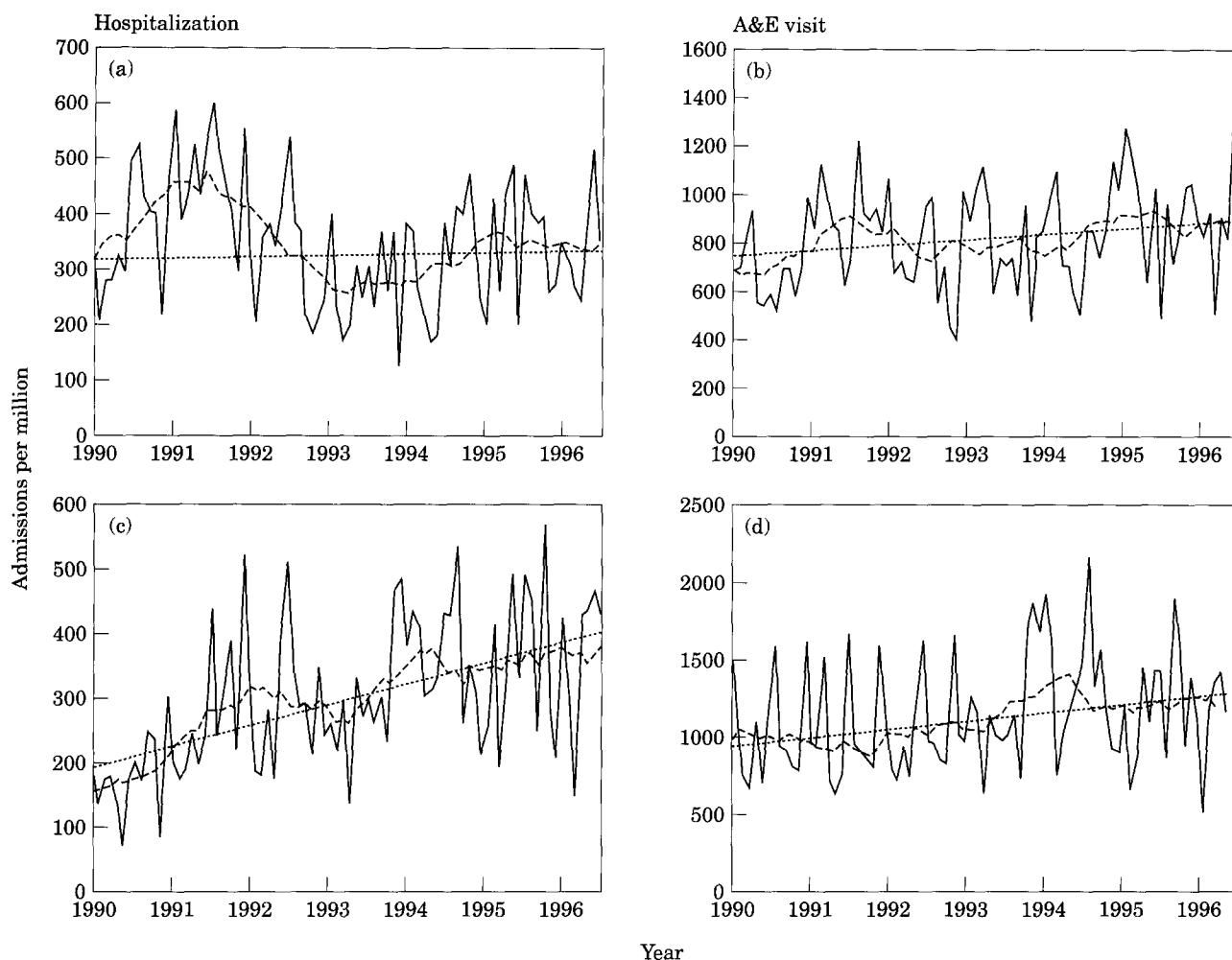


FIG. 1 Monthly hospital admissions and Accident and Emergency (A&E) visits for asthma (ICD 493,—) with the 12-months moving average trends (---) and overall period trends (···) in Singapore, 1990–1996. (a,b) 0–2 years, (c,d) 3–12 years.

When the variation in the demographic profile of those admitted for asthma over the period analysed were evaluated, the ratios for sex and ethnic groups remained relatively stable over this period (Fig. 3). Similar findings were observed for variations between age groups, with the exception of 1991 where an increased proportion of the 0–2 year olds was documented (Fig. 3).

### SEASONAL VARIATION

With asthma, the seasonal variation profile for A&E visits for all ages showed distinct peaks in January–February, May and August each year, with a maximum usually in January (33% above the trend). Troughs were present in March, June–July and November–December, with the annual lowest in June (40% below the trend). The test for seasonality was found to be significant ( $\chi^2=16.2$ ,  $P<0.05$ ). The monthly average percentage variations for asthma and acute bronchitis/bronchiolitis according to age groups are shown in Fig. 4. A similar seasonal profile was observed for

A&E visits for asthma in both the 0–2 and 3–12 years age groups. The test for seasonality was only significant for the 3–12 years group. ( $\chi^2=22.1$ ,  $P<0.05$ ). Comparable peaks were noted for hospital admissions for both age groups, although the major admission periods were mainly in January and August (extending to October), with a maximum in August (35% above the trend). As with A&E visits, low admission periods occurred in March, June and December. The test for seasonality for both age groups was, however, not significant.

The seasonal peaks for acute bronchitis/bronchiolitis did not coincide with those observed for asthma. Hospital admissions for acute bronchitis peaked above the trend in the first half of the year for both age groups. The test for seasonality for these variational patterns were, however, only significant for acute bronchitis among the 0–2 year olds. With A&E visits, no significant seasonal pattern prevailed in both age groups.

When data of both hospitals were analysed separately, similar trends and seasonal variations were also observed (data not shown).

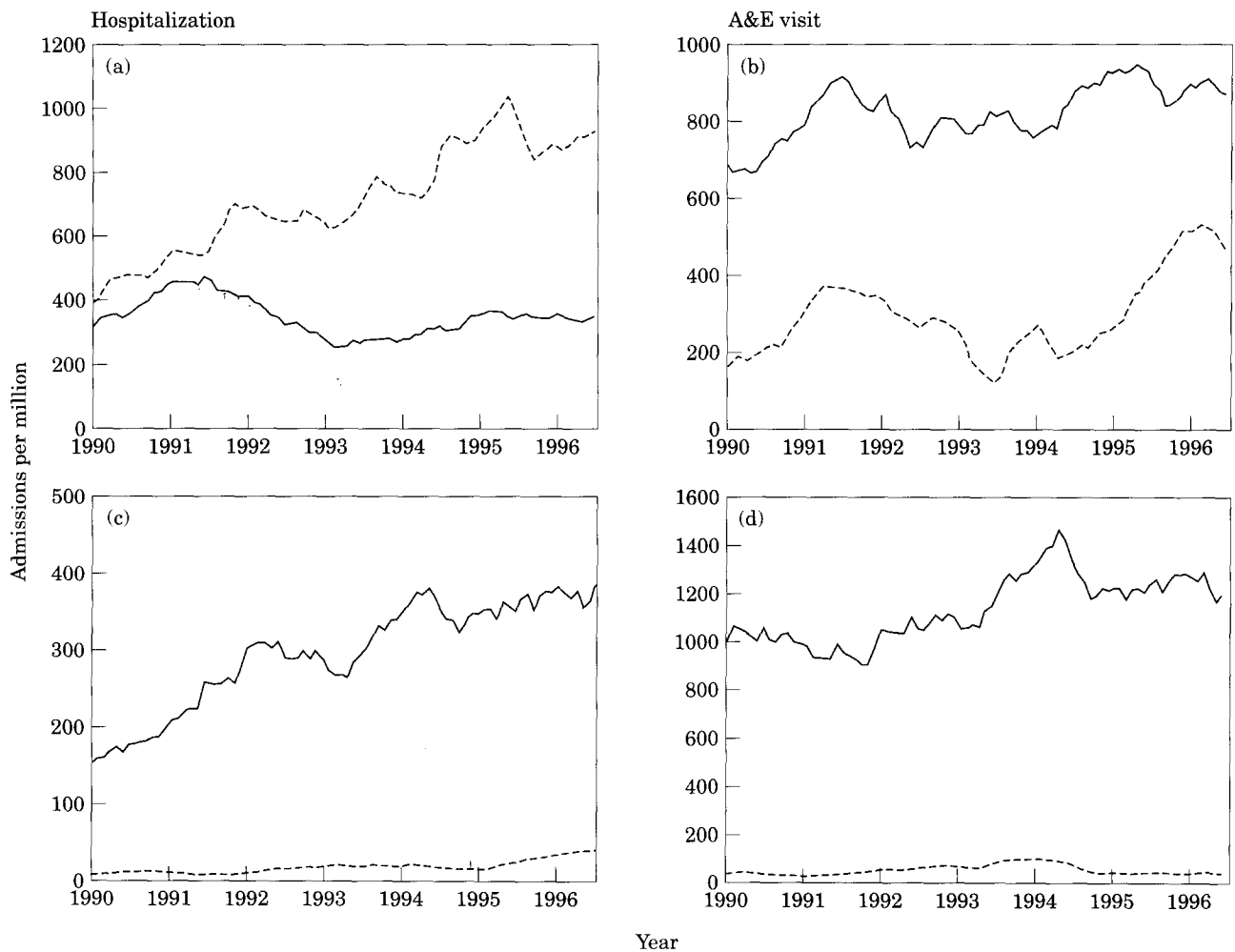


FIG. 2 Trends in hospital admissions and Accident and Emergency (A&E) visits for asthma (ICD 493, —) compared with acute bronchitis/bronchiolitis (ICD 466, ---) in Singapore, 1990–1996. (a,b) 0–2 years, (c,d) 3–12 years.

## Discussion

Asthma morbidity is known to show seasonal periodicity in temperate regions, (3–5). Although not as pronounced, the authors have demonstrated seasonality in acute childhood asthma in Singapore's tropical environment. The factors responsible for this seasonality, such as changing weather, variation in mite allergen levels, viral infections, pollen and fungal spore loads, and air pollution, have been implicated (5).

Locally, weather and house dust mite allergens are unlikely factors. The only striking seasonal changes in weather, which arise from monsoon winds, are wind speed and direction, and rainfall. The 'wet season' between October and April, with highest rainfall in December, and the 'dry season' in July and August did not correlate with the asthma admissions nor A&E visits (unpubl. data). Although the majority of studied asthmatics were sensitive to the house dust mite, and dust mites are prevalent in their homes, no significant seasonal variation in mite allergen levels occur in Singapore's tropical climate (6).

Viral infections are also important triggers of asthma symptoms during childhood. From virus isolation data of the authors' hospital laboratories, seasonality has been noted in hospital admissions, with influenza virus peaking in November–January and in June, and respiratory syncytial virus peaking between April and June. These seasons did not coincide with those of acute asthma (7), even though this analysis included all children below the age of 12 years. Furthermore, the data from this study did not reveal any similarities between the trends and seasonal variations for acute asthma and acute bronchitis/bronchiolitis for both the 0–2 and 2–13 years, age groups, an indication that the respiratory viruses responsible for the trends in acute bronchitis/bronchiolitis did not appear to influence those for acute asthma. Based on virus isolation data, the impact of other respiratory viruses, such as rhinoviruses or parainfluenza virus, on acute asthma could not be fully evaluated as the numbers were few and sporadic (7). However, in a previous local study, only approximately 20% had a respiratory viral infection documented (by serology or isolation) (8). This finding is contrary to a study in schoolchildren in the U.K. which

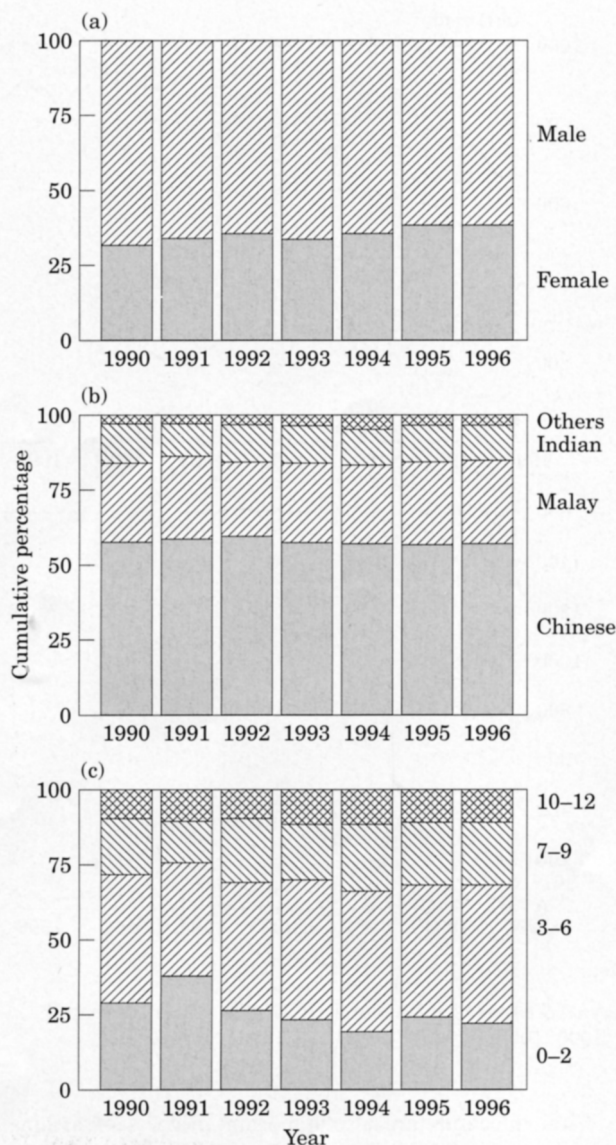


FIG. 3. The comparative (a) sex, (b) ethnic group and (c) age group ratios for children (12 years and below) admitted for asthma (ICD 493) in Singapore over the period 1990–1996.

reported documented upper respiratory viral infections in 80–85% of asthma exacerbations in school age children (9).

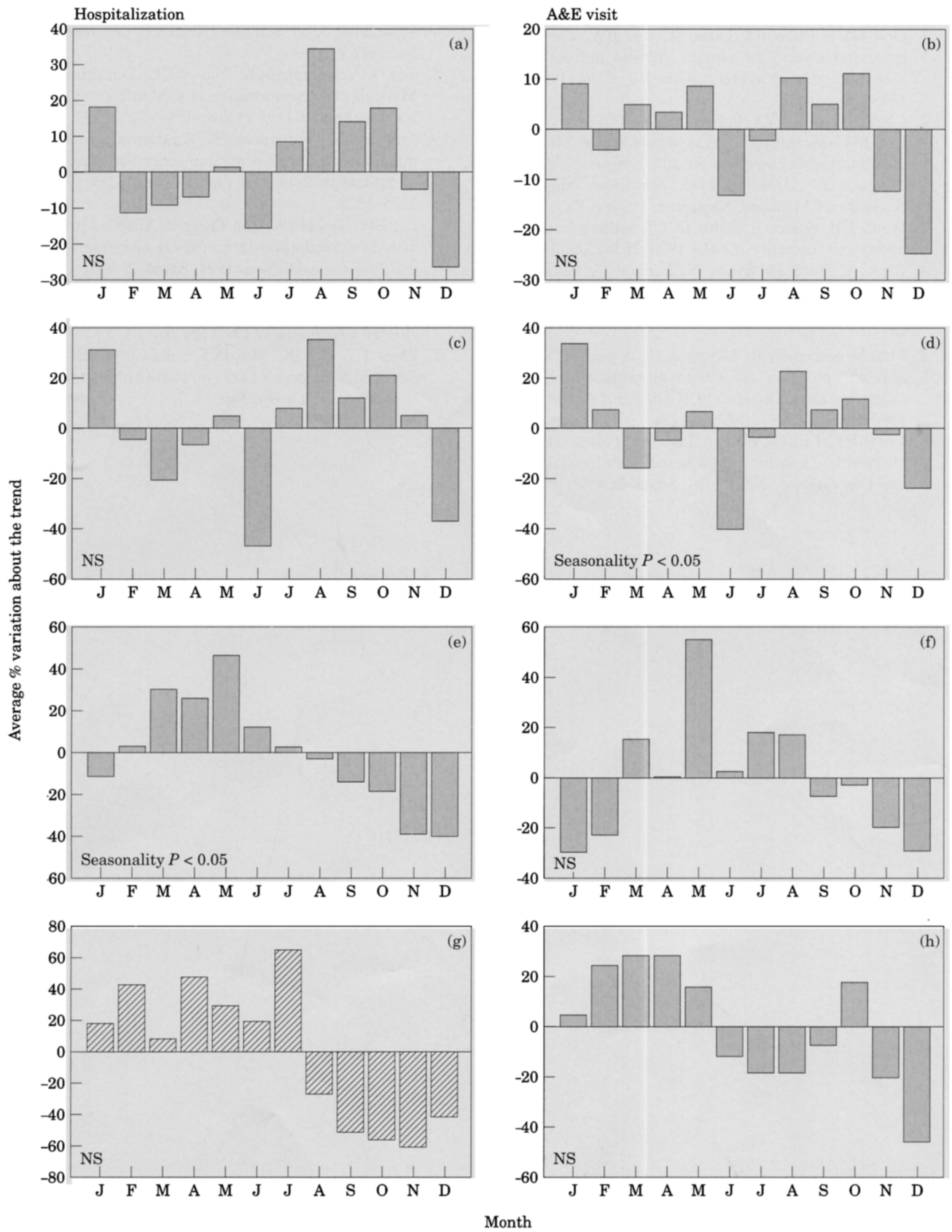
Interestingly, the fungal airspora peaks in the study environment appear to coincide with the asthma peaks. From the airspora survey of this environment, the authors recorded four fungal peaks occurring in January, April–May, August–September and November which were significantly associated with the peaks for asthma (10), suggesting a role of fungal spore allergy in triggering asthma exacerbations in the study population. The authors' recent study also showed that asthma exacerbation was associated with local ambient air pollution levels (11). This association was further strengthened when increased air pollution and heavy haze due to forest fires and volcano eruptions in neighbouring countries resulted in marked increases in acute asthma (12). These episodes of increased air pollution may have influenced the upward asthma trends of 1991 and 1994 observed in this study.

This study has provided an indication of acute asthma 'seasons' in Singapore. Although it was most pronounced in the 3–12 years age group and for A&E visits, the 0–2 years age group and hospitalization data also followed very similar trends. In addition, even though fluctuations in the trend over the study period were noted, the seasonal pattern remained constant. A combination of triggering factors, particularly ambient air pollution and airspora, may be involved, possibly in a synergistic manner. Further multivariate analysis and clinical studies will, however, be necessary to confirm these findings.

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FIG. 4. Seasonal variation in the monthly hospitalization and Accident and Emergency (A&E) visit rates for childhood acute bronchitis/bronchiolitis (ICD 466) and asthma (ICD 493) in Singapore, 1990–1996, as shown as the average percentage variation about the trend for the months of January–December. NS, not significant seasonality. (a,b) asthma (ICD 493), 0–2 years; (c,d) asthma (ICD 493), 3–12 years; (e,f) acute bronchitis/bronchiolitis (ICD 466), 0–2 years; (g,h) acute bronchitis/bronchiolitis (ICD 466), 3–12 years.



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